Q1: Broadest or hardest?

- Should ARPA-E aim to improve technologies for the broadest possible number of cases or focus on the hardest technical cases?
  - Urban/suburban/rural
    - Hardest challenges are **boring in urban/high density areas**
      - Suburban/rural may also include swamps/water, protected areas, environmental concerns, but much easier overall
    - **Mapping technology** and access/use of mapping data is a broad challenge
      - Difficult to go deep enough to avoid mapping (lots of 20+ foot deep lines)
  - Primary 3-phase main feeder/primary 3-phase laterals/secondary laterals to a single meter
    - All of these are the same general techniques, just different sizes
  - Maintenance for overhead infrastructure is a harder challenge than new construction
    - But a focus on new construction and undergrounding could reduce costs associated with repair/maintenance over lifetime of installations

Q2: Where are the costs?

- "Other" - Repaving, restoring landscape, compensating impacted persons
- Environmental assessment/EIS, locating
- **Locating foreign utility line crossings** (and rarely, geological barriers)
- Remainder:
  - ~50% materials/equipment
  - ~50% labor
    - Boring is ~60% of the time cost
    - Depends on knowledge of the path, less so on soil conditions
    - **Real-time collision detection and avoidance technology**
- Life-cycle costing (vs overhead, 30-40 year life) argues for undergrounding
  - Every undergrounding activity is VERY site-specific
  - But upfront costs remain a barrier

Q3: Program prioritizing components or systems?

- Component-level solutions (e.g., borehole drilling, conduit installation, vault construction, vertical access points, cable pulling)
  - **Boring/trenching is the long pole in the tent**
    - Also the highest risk to personnel
  - Cable setting, pulling, terminating all less costly
  - Failures occur at
    - Terminations
    - Inline splices
    - Cable body (distant third place) – either mfg defect or someone else impacted/crushed the conduit
- System-level solutions in the underground construction category
  - **Sub-system level solutions might be the sweet spot**